

DIN EN 16603-35-06

ICS 49.140

Ersatz für
DIN EN 16603-35-06:2014-12**Raumfahrttechnik –
Sauberkeitsanforderungen für die Antriebstechnik von Raumfahrzeugen;
Englische Fassung EN 16603-35-06:2022**

Space engineering –
Cleanliness requirements for spacecraft propulsion hardware;
English version EN 16603-35-06:2022

Ingénierie spatiale –
Exigences de propreté du matériel de propulsion des engins spatiaux;
Version anglaise EN 16603-35-06:2022

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Nationales Vorwort

Dieses Dokument (EN 16603-35-06:2022) wurde vom Technischen Komitee CEN/CLC/JTC 5 „Raumfahrt“ erarbeitet, dessen Sekretariat von DIN (Deutschland) gehalten wird.

Das zuständige deutsche Normungsgremium ist der Arbeitsausschuss NA 131-06-02 AA „Interoperabilität von Informations-, Kommunikations- und Navigationssystemen“ im DIN-Normenausschuss Luft- und Raumfahrt (NL).

Dieses Dokument enthält unter Berücksichtigung des Präsidialbeschlusses 1/2004 nur die englische Originalfassung von EN 16603-35-06:2022.

Dieses Dokument wurde speziell zur Behandlung von Raumfahrtssystemen erarbeitet und hat daher Vorrang vor jeder anderen EN-Norm, die denselben Anwendungsbereich abdeckt, aber einen breiter gefassten Geltungsbereich besitzt (z. B. Luft- und Raumfahrt).

Aktuelle Informationen zu diesem Dokument können über die Internetseiten von DIN (www.din.de) durch eine Suche nach der Dokumentennummer aufgerufen werden.

Änderungen

Gegenüber DIN EN 16603-35-06:2014-12 wurden folgende Änderungen vorgenommen:

- a) Umsetzung der eingegangenen Änderungswünsche auf den ECSS-äquivalenten Standard;
- b) Ergänzung der Nomenklatur in 3.5;
- c) Definition von „Genauigkeit“ in 3.2 gelöscht und Verweisung auf ECSS-S-ST-00-01 in 3.1 aufgenommen;
- d) Definition „kondensierbarer Kohlenwasserstoff“ und „Dewar“ in 3.2 gestrichen, da sie in der Norm nicht verwendet wurden;
- e) geänderte Anforderungen: 4.1h Anmerkung 2 (Verweisung auf Bild einer anderen ECSS-Norm korrigiert); 6.2.6.2a; 6.4.3a; 6.4.3c; 12.1a; 12.2c Anmerkung zu Punkt 10 an das Ende der Anforderung verschoben;
- f) verschachtelte Anmerkungen in Anforderung 12.1a an das Ende der Anforderung verschoben;
- g) Querverweis in B.1.1 auf hinzugefügte Anforderung 6.4.3d erstellt;
- h) Überschrift der Tabelle in Anhang D von „Tabelle A-1“ in „Tabelle D-1“ korrigiert;
- i) redaktionelle Überarbeitung.

Frühere Ausgaben

DIN EN 16603-35-06: 2014-12

Nationaler Anhang NA (informativ)

Begriffe und Abkürzungen

Reihenfolge und Inhalt der folgenden Begriffe sind identisch mit denen im Abschnitt Begriffe der englischen Fassung.

3 Begriffe und Abkürzungen

3.1 Begriffe aus anderen Normen

a) Für die Anwendung dieser Norm gelten die Begriffe nach ECSS-S-ST-00-01, besonders die folgenden Begriffe:

1) Genauigkeit

b) Für die Anwendung dieser Norm gelten die Begriffe nach ECSS-E-ST-35.

3.2 Für diese Norm spezifische Begriffe

3.2.1

Blindprobe

Ergebnis für eine Analysenprobe der unbenutzten Prüflüssigkeit vor der Verwendung bei der Durchführung einer Reinheitsüberprüfung

3.2.2

Reinheitsüberprüfung

Sauberkeitsüberprüfung

Tätigkeit zur Überprüfung, ob die tatsächlichen Bedingungen für die Reinheit/Sauberkeit eines Erzeugnisses die geltende Spezifikation erfüllen

3.2.3

Haarrissbildung

Bildung von Mikroporen in glasartigen thermoplastischen Polymeren, die einer Rissbildung vorausgeht

3.2.4

kritische Oberfläche

jegliche Oberfläche eines Erzeugnisses, die in Berührung mit dem Betriebsmedium kommt

Anmerkung zum Begriff: Beispiele für Betriebsmedien sind Treibstoffe und Verdrängungsgase.

3.2.5

Taupunkt

Temperatur, bei der die Kondensation von Wasserdampf beim vorherrschenden Druck stattfindet

Anmerkung zum Begriff: Der vorherrschende Druck ist üblicherweise der Atmosphärendruck.

3.2.6

Faser

flexible Struktur mit einem Längen-Breiten-Verhältnis von 10 : 1 oder mehr

Anmerkung 1 zum Begriff: Eine Faser wird als eine Partikel betrachtet, siehe 3.2.11.

Anmerkung 2 zum Begriff: Als Fasergröße gilt deren maximale Länge.

3.2.7

Reinigung vor Ort

Vorgang der Vorreinigung und Feinreinigung von Komponenten, Untersystemen und Systemen, die nicht in einer kontrollierten Umgebung, wie z. B. einem Reinraum, durchgeführt werden können

3.2.8

allgemein sauber

frei von Fertigungsrückständen, Schmutz, Öl, Schmierfett, Verarbeitungsrückständen oder anderen Fremdverunreinigungen, beurteilt durch Sichtprüfung

3.2.9

hochwirksamer Schwebstofffilter

Filter mit einem nach Volumen bemessenen Wirkungsgrad von mindestens 99,97 % bei einer Partikelgröße von 0,3 µm

3.2.10

nichtflüchtiger Rückstand

lösliche oder suspendierte Stoffe und unlösliche Schwebstoffe, die nach einer temperaturkontrollierten Verdampfung einer flüchtigen Flüssigkeit verbleiben

Anmerkung zum Begriff: Siehe auch 6.2.4.3.

3.2.11

Partikel

Einheit eines Feststoffes von feststellbarer Größe

Anmerkung 1 zum Begriff: Zur Bestimmung ihrer Größe können unterschiedliche Verfahren angewendet werden, die vom Messverfahren abhängig sind.

Anmerkung 2 zum Begriff: Bei einem manuellen Verfahren ist die Partikelgröße die scheinbare maximale lineare Abmessung einer Partikel, die in der Betrachtungsebene mithilfe von Geräten, wie z.B. optisches Mikroskop, Elektronenmikroskop oder Rasterkraftmikroskop, beobachtet wird.

Anmerkung 3 zum Begriff: Bei einem automatischen Verfahren ist die Partikelgröße der äquivalente Durchmesser einer Partikel, der durch automatische Messgeräte ermittelt wird.

Anmerkung 4 zum Begriff: Der äquivalente Durchmesser ist der Durchmesser einer Referenzkugel mit bekannten Eigenschaften, die die gleiche Reaktion im Messgerät erzeugt wie die zu messende Partikel.

Anmerkung 5 zum Begriff: Eine Faser wird als eine Partikel betrachtet, siehe 3.2.6.

3.2.12

Passivierung

Vorgang, bei dem eine korrosionsbeständige Schicht auf einer Metalloberfläche durch Eintauchen der Oberfläche in eine Säurelösung gebildet wird

3.2.13

Beizen

chemischer oder elektrochemischer Vorgang, bei dem Oberflächenoxide von Metallen entfernt werden

3.2.14

Feinreinigung

Reinigungsvorgang, der zum Erreichen höherer Reinheitsgrade als „sichtbar rein“ angewendet wird

3.2.15

Vorreinigung

Reinigungsvorgang, der üblicherweise zum Erreichen des Reinheitsgrades „sichtbar rein“ angewendet wird

3.2.16**Reversion**

Abnahme der Viskosität, der Festigkeit oder des Gummi-Elastizitätsmoduls infolge von Erhitzung oder Überbeanspruchung, die zu einem klebrigen und weichen Material führt

3.2.17**Ablagerung**

Ansammlung von Partikeln in ausreichender Menge, um eine Trübung oder Verdunkelung eines Teils einer Filtermembran zu verursachen, wenn durch Sichtprüfung oder unter 40-facher maximaler Vergrößerung untersucht wird

3.2.18**Prüfflüssigkeit**

vorgegebene Flüssigkeit, die zur Bestimmung des Reinheitsgrades der benetzten Oberfläche des Fluidsystems verwendet wird

3.2.19**höchstzulässige Konzentration****Schwellenwert**

en **threshold limit value**

maximale durchschnittliche Tagesdosis an gefährlichen Chemikalien, der eine durchschnittliche Arbeitskraft, ausgehend von einem 8-stündigen Arbeitstag und einer 5-tägigen Arbeitswoche, ohne schädigende Auswirkungen ausgesetzt sein darf

Anmerkung 1 zum Begriff: Die TLV ist eine zeitlich gewichtete Durchschnittskonzentration.

Anmerkung 2 zum Begriff: Die TLV wird üblicherweise in Teilen des Gases oder Dampfes in Mikroliter je Liter angegeben.

3.2.20**sichtbar rein**

Nichtvorhandensein einer Oberflächenverunreinigung bei einer Prüfung mit einer bestimmten Lichtquelle, unter einem bestimmten Einfallswinkel und in einem bestimmten Sichtabstand, untersucht durch Sichtprüfung oder mit bis zu 20-facher Vergrößerung

3.2.21**sichtbar rein plus Ultraviolett-Licht**

Reinheitsgrad „sichtbar rein“, der auch die Anforderungen an eine Prüfung mit Hilfe von UV-Licht der Wellenlänge 250 nm bis 395 nm erfüllt

3.2.22**flüchtiger Kohlenwasserstoff**

Kohlenwasserstoff, der bei Umgebungstemperatur und Umgebungsdruck aus einem flüssigen oder festen Zustand in einen gasförmigen Zustand übergehen kann

3.3 Abkürzungen

Für die Anwendung dieser Norm gelten die Abkürzungen nach ECSS-S-ST-00-01 und die folgenden Abkürzungen:

Abkürzung	Bedeutung	
CC	Reinheitszertifikat	(en: cleanliness certificate)
CRA	Analyse des Reinigungsbedarfs	(en: cleaning requirement analysis)
CTS	Wahl des Reinigungsverfahrens	(en: cleaning technique selection)
GC	allgemeine Sauberkeit	(en: generally clean)
HEPA	hochwirksamer Schwebstofffilter	(en: high-efficiency particulate air filter)
HFE	Hydrofluorether (Perfluor-n-Butylmethylether)	[en: hydro fluor ether (Perfluoro-n-butyl methyl ether)]
IPA	Isopropanol	(en: isopropanol)
MAIT	Herstellung, Montage, Einbau und Prüfung	(en: manufacturing, assembly, integration and test)
MEK	Methylethylketon	(en: methyl ethyl keton)
MS	Massenspektroskopie	(en: mass spectroscopy)
NVR	nichtflüchtiger Rückstand	(en: non-volatile residue)
ppmv	Teile pro Million, volumetrisch	(en: parts per million, volumetric)
TLV	höchstzulässige Konzentration (Schwellenwert)	(en: threshold limit value)
US	Ultraschall	(en: ultra sonic)
VC	sichtbar rein	(en: visibly clean)
VC+UV	sichtbar rein plus Ultraviolett-Licht	(en: visibly clean plus ultraviolet)

EUROPEAN STANDARD

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NORME EUROPÉENNE

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English version

Space engineering - Cleanliness requirements for spacecraft propulsion hardware

Ingénierie spatiale - Exigences de propreté du matériel
de propulsion des engins spatiaux

Raumfahrttechnik - Sauberkeitsanforderungen für die
Antriebstechnik von Raumfahrzeugen

This European Standard was approved by CEN on 20 April 2022.

CEN and CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CEN and CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN and CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

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European Foreword

This document (EN 16602-20-07:2016) has been prepared by Technical Committee CEN-CENELEC/TC 5 “Space”, the secretariat of which is held by DIN.

This standard (EN 16602-20-07:2016) originates from ECSS-Q-ST-20-07C.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by January 2023, and conflicting national standards shall be withdrawn at the latest by January 2023.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 16603-35-06:2014.

The main changes with respect to EN 16603-35-06:2014 are listed below:

- Implementation of Change Requests received to the ECSS equivalent standard
- Addition of the Nomenclature in clause 3.5
- Definition of “accuracy” deleted in 3.2 and reference to ECSS-S-ST-00-01 made in 3.1
- Definition “condensable hydrocarbon” and “dewar” deleted in clause 3.2 as they were not used in the standard
- Added requirements 6.4.3d.
- Modified requirements: 4.1h Note 2 (reference to Figure of other ECSS Standard corrected); 6.2.6.2a; 6.4.3a; 6.4.3c; 12.1a; 12.2c Note to item 10 moved to the end of the requirement.
- Interleaved Notes in requirement 12.1a move to the end of the requirement
- Cross-reference in Annex B.1.1 to added requirement 6.4.3d created
- Caption of Table in Annex D corrected from “Table A-1” to “Table D-1”.

This document has been prepared under a standardization request given to CEN by the European Commission and the European Free Trade Association.

This document has been developed to cover specifically space systems and has therefore precedence over any EN covering the same scope but with a wider domain of applicability (e.g. : aerospace).

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

1

Scope

ECSS-E-ST-35-06 belongs to the Propulsion field of the mechanical discipline, and concerns itself with the cleanliness of propulsion components, sub-systems and systems

The standard

- defines design requirements which allow for cleaning of propulsion components sub-systems and systems and which avoid generation or unwanted collection of contamination,
- identifies cleanliness requirements (e.g. which particle / impurity / wetness level can be tolerated),
- defines requirements on cleaning to comply with the cleanliness level requirements, and the requirements on verification,
- identifies the cleanliness approach, cleaning requirements, (e.g. what needs to be done to ensure the tolerable level is not exceeded, compatibility requirements),
- identifies, specifies and defines the requirements regarding conditions under which cleaning or cleanliness verification takes place (e.g. compatibility, check after environmental test).

The standard is applicable to the most commonly used propulsion systems and their related storable propellant combinations: Hydrazine (N_2H_4), Mono Methyl Hydrazine ($\text{CH}_3\text{N}_2\text{H}_3$), MON (Mixed Oxides of Nitrogen), Nitrogen (N_2), Helium (He), Propane (C_3H_8), Butane (C_4H_{10}) and Xenon (Xe).

This standard is the basis for the European spacecraft and spacecraft propulsion industry to define, achieve and verify the required cleanliness levels in spacecraft propulsion systems.

This standard is particularly applicable to spacecraft propulsion as used for satellites and (manned) spacecraft and any of such projects including its ground support equipment.

External cleanliness requirements, e.g. outside of tanks, piping and aspects such as fungus and outgassing are covered by ECSS-Q-ST-70-01.

This standard may be tailored for the specific characteristic and constraints of a space project in conformance with ECSS-S-ST-00.

Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this ECSS Standard. For dated references, subsequent amendments to, or revisions of any of these publications, do not apply. However, parties to agreements based on this ECSS Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references the latest edition of the publication referred to applies.

EN reference	Reference in text	Title
EN 16601-00	ECSS-S-ST-00-01	ECSS system — Glossary of terms
EN 16603-35	ECSS-E-ST-35	Space engineering — Propulsion general requirements
EN 16602-40	ECSS-Q-ST-40	Space product assurance — Safety
EN 16602-70-01	ECSS-Q-ST-70-01	Space product assurance — Cleanliness and contamination control.
EN 16602-70	ECSS-Q-ST-70	Space product assurance — Materials, mechanical parts and processes
	ISO 2210:1972	Liquid halogenated hydrocarbons for industrial use- Determination of residue on evaporation
	ISO 5789:1979	Fluorinated hydrocarbons for industrial use — Determination of non-volatile residue
	ISO 5884:1987	Aerospace — Fluid systems and components — Methods for system sampling and measuring the solid particle contamination of hydraulic fluids
	ISO 14951-3:2000	Space systems — Fluid characteristics — Part 3: Nitrogen
	ISO 14951-4:2000	Space systems — Fluid characteristics — Part 4: Helium
	ISO 14951-10:2000	Space systems — Fluid characteristics — Part 10: Water
	ISO 14952-3:2003	Space systems — Surface cleanliness of fluid systems — Part 3: Analytical procedures for the determination of non-volatile residues and particulate contamination
	ASTM D257(99) 2005	Standard Test Method for DC Resistance or Conductance of Insulating Materials
	ASTM D329 10 Dec 2002	Standard specification for Acetone

EN reference	Reference in text	Title
	ASTM D740 15 May 2005	Standard specification for Methyl Ethyl Ketone
	ASTM D770-05 15 May 2005	Standard specification for Isopropyl Alcohol
	ASTM D1152 1 Apr 2006	Standard specification for Methanol (Methyl Alcohol)
	ASTM D1293 10 Dec 1999	Standard test methods for pH of water
	ASTM D4376	Standard specification for vapor-degreasing grade Perchloroethylene
	MIL-PRF-27415B 8 Feb 2007	Performance specification, propellant pressurizing agent, Argon
	O-E-760D 28 May 1987	Federal specification
	SEMI C47-0699 May 1999	Guideline for Trans 1,2 Dichloroethylene

Terms, definitions and abbreviated terms

3.1 Terms from other standards

- a. For the purpose of this Standard, the terms and definitions from ECSS-S-ST-00-01 apply, in particular for the following term:
 - 1. accuracy
- b. For the purpose of this Standard, the terms and definitions from ECSS-E-ST-35 apply.

3.2 Terms specific to the present standard

3.2.1 blank

result for an analytical sample of the virgin test fluid prior to use in performing a cleanliness verification test

3.2.2 cleanliness verification

activity intended to verify that the actual cleanliness conditions of an item are in conformance with the applicable specification

3.2.3 crazing

creating microvoids in glassy thermoplastic polymers preceding the formation of cracks

3.2.4 critical surface

any surface of an item that contacts the service medium

NOTE Examples of service media are propellants and pressurants.

3.2.5 dew point

temperature at which condensation of water vapour takes place at prevailing pressure

NOTE The prevailing pressure is usually atmospheric pressure.

3.2.6 fibre

flexible structure having a length-to-width ratio of 10 to 1 or greater

NOTE 1 A fibre is considered to be a particle, see clause 3.2.11.

NOTE 2 The size of a fibre is its maximum length.

3.2.7 field cleaning

processes of pre-cleaning and precision cleaning of components, subsystems and systems which cannot be processed in a controlled environment such as a clean room

3.2.8 generally clean

free from manufacturing residue, dirt, oil, grease, processing debris, or other extraneous contamination based on visual examination

3.2.9 high-efficiency particulate air filter

filter that is at least 99,97 % efficient by volume on 0,3 µm particles

3.2.10 non-volatile residue

soluble or suspended material and insoluble particulate matter remaining after temperature-controlled evaporation of a volatile liquid

NOTE See also clause 6.2.4.3

3.2.11 particle

unit of solid matter with observable size

NOTE 1 Various methods for defining its size may be used and are dependant upon the measurement technique.

NOTE 2 For the manual method the apparent maximum linear dimension of a particle in the plane of observation as observed with instruments such as optical, electron, or atomic force microscopes is the particle size.

NOTE 3 For the automatic method, the equivalent diameter of a particle detected by automatic instrumentation is the particle size.

NOTE 4 The equivalent diameter is the diameter of a reference sphere having known properties and producing the same response in the sensing instrument as the particle being measured.

NOTE 5 A fibre is considered a particle, see clause 3.2.6.

3.2.12 passivation

process by which a corrosion-resistant layer is formed on a metal surface by submersing the surface in an acid solution

3.2.13 pickling

chemical or electrochemical process by which surface oxides are removed from metals

3.2.14 precision cleaning

cleaning process used to achieve cleanliness levels more stringent than visibly clean

3.2.15 pre-cleaning

cleaning process normally used to achieve the visibly clean cleanliness level

3.2.16 reversion

decrease in viscosity, strength, or in rubber modulus due to heating or overworking, resulting in a tacky and soft material

3.2.17 silting

accumulation of particles of sufficient quantity to cause a haze or obscuring of any portion of a filter membrane when viewed visually or under 40-power maximum magnification

3.2.18 test fluid

specified fluid that is utilized to determine the fluid system wetted-surface cleanliness level

3.2.19 threshold limit value

maximum average daily dosage, based on an 8-h day, 5-day week, to which an average worker may be exposed to hazardous chemicals without harmful effect

NOTE 1 The TLV is a time-weighted average concentration.

NOTE 2 The TLV is normally expressed in parts of the gas or vapour in micro litres per litre.

3.2.20 visibly clean

absence of surface contamination when examined with a specific light source, angle of incidence, and viewing distance using normal or magnified vision up to $\times 20$

3.2.21 visibly clean plus ultraviolet

cleaning level that is visibly clean and also meets the requirements for inspection with the aid of an ultraviolet light of wavelength 250 nm to 395 nm

3.2.22 volatile hydrocarbon

hydrocarbon capable of going from liquid or solid to a gaseous state at ambient temperature and pressure

3.3 Abbreviated terms

For the purpose of this Standard, the abbreviated terms from ECSS-S-ST-00-01 and the following apply:

Abbreviation	Meaning
CC	cleanliness certificate
CRA	cleaning requirement analysis
CTS	cleaning technique selection
GC	generally clean

HEPA	high-efficiency particulate air filter
HFE	hydro fluor ether (Per fluoro-n-butyl methyl ether)
IPA	isopropanol
MAIT	manufacturing, assembly, integration and test
MEK	methyl ethyl keton
MS	mass spectroscopy
NVR	non-volatile residue
ppmv	parts per million, volumetric
TLV	threshold limit value
US	ultra sonic
VC	visibly clean
VC + UV	visibly clean plus ultraviolet

3.4 Symbols

Symbol	Meaning
d_p	mean pore diameter of a filter

3.5 Nomenclature

The following nomenclature applies throughout this document:

- c. The word “shall” is used in this Standard to express requirements. All the requirements are expressed with the word “shall”.
- d. The word “should” is used in this Standard to express recommendations. All the recommendations are expressed with the word “should”.

NOTE It is expected that, during tailoring, recommendations in this document are either converted into requirements or tailored out.

- e. The words “may” and “need not” are used in this Standard to express positive and negative permissions, respectively. All the positive permissions are expressed with the word “may”. All the negative permissions are expressed with the words “need not”.
- f. The word “can” is used in this Standard to express capabilities or possibilities, and therefore, if not accompanied by one of the previous words, it implies descriptive text.

NOTE In ECSS “may” and “can” have completely different meanings: “may” is normative (permission), and “can” is descriptive.

- g. The present and past tenses are used in this Standard to express statements of fact, and therefore they imply descriptive text.

Cleanliness requirements

4.1 General

- a. This standard shall only apply to propulsion systems using Hydrazines, MON, Propane, Butane, Nitrogen, Helium, Xenon as propellants.
- b. Cleanliness assurance precautions and features shall be specified and incorporated in the hardware at the design phase.

NOTE In propulsion systems cleanliness is a major requirement to avoid loss of function and performance.

- c. Cleanliness verification shall be applied at progressive MAIT stages in the process.
- d. The hardware shall be designed to enable post-build cleaning and cleanliness verification.
- e. Operation and use shall not generate or release contamination.
- f. A cleanliness verification should be performed successively at component, sub-system and system level prior to a blind-end close-out.
- g. Cleanliness Particle Count levels shall be to a lower required class or subclass at the early hardware build and verification stages, than the final product.

NOTE 1 This allows final system-level cleanliness to be achieved.

NOTE 2 See Table 4-1 for cleanliness classes and subclasses.

- h. During the design phase the necessity of cleanliness verification shall be assessed.

NOTE 1 This applies from components to the design of systems, and to operations as not to generate contamination and to enable cleaning.

NOTE 2 Figure C-1 of ECSS-Q-ST-70-01 gives an overview of space system cleanliness requirements organized in a cleanliness control flow chart.

- i. Compatibility of cleaning fluids with the propulsion system materials and propellants shall be established in conformance with Annex A.

NOTE 1 For efficient cleaning chemical compounds like alkaline and acid cleaners are required.

NOTE 2 Related requirements are specified in ECSS-E-ST-35-10, 'Known incompatibilities' concerning compatibility testing for liquid propulsion components, subsystems and systems.

- j. All components, subsystems, systems or related equipment for use in ground support equipment and spacecraft requiring cleaning shall be
 - 1. cleaned to the specified cleanliness level, in conformance with the CRA produced in conformance with Annex A,
 - 2. inspected in conformance with Annex B.
- k. The results of 4.1j shall be reported in conformance with Annex C.
- l. Any component, subsystem or system that can be damaged during cleaning shall be:
 - 1. protected or removed before cleaning;
 - 2. cleaned as a separate item in conformance with the CTS produced in conformance with Annex B.
- m. Cleaning or disassembly operations on precision components shall be performed only by personnel who have been trained and certified to perform these functions.

4.2 Design requirements

4.2.1 General

- a. Designs shall be such that the product
 - 1. avoids contamination and
 - 2. allows for cleaning and drying.
- b. Cleanliness classes shall be established in conformance with Annex A, to apply to propulsion components, subsystems and systems.

4.2.2 Components

4.2.2.1 Tanks

- a. Tank internal structures shall not shed particles during operation.
- b. Tank internal structures shall allow for draining and cleaning.

NOTE Examples of such structures are diaphragms, bladders, baffles, and surface tension screens.

4.2.2.2 Tubing and manifolds

- a. Tubings and manifolds should avoid stepped diameter transitions that create turbulence or flow separation.

NOTE Turbulent flows and wakes can cause particle deposition.
- b. Tubings and manifolds should avoid blind holes and dead ends,
- c. Tubings and manifolds shall avoid internal threads.

NOTE The risk of contamination is increased with the number of screw joints.

4.2.2.3 Valves and regulators

- a. Solenoid valves should use flexure guided armatures.

NOTE Sliding surfaces can jam or generate particles.

- b. Valve or regulator function and performance shall be independent from lubrication on critical surfaces.

- c. Fluid paths should be smooth, avoiding stepped transitions.

NOTE This is to avoid entrapment of contamination.

- d. Valve or regulator parts and assembled parts should allow for ultrasonic cleaning, in conformance with the CTS produced in conformance with Annex B.

- e. Protective filters shall be dimensioned in conformance with the CRA produced in conformance with Annex A, such that the selected filtration rate does not allow particles exceeding a specified size, to pass, thereby degrading function and performance.

- f. Reference ports on regulators shall be protected by filters.

- g. In conformance with the CRA produced in conformance with Annex A, protective filters shall be dimensioned such that the specified accumulated contamination causes no pressure drop exceeding the requirement.

- h. Valve- or regulator-poppet design shall avoid entrapment of contamination.

- i. A valve or regulator assembly should allow for the integration of protective filters after the final cleaning of the unit has been performed and verified in conformance with the CTS produced in conformance with Annex B.

- j. Valves and regulators subject to reverse flow shall incorporate an outlet filter.

- k. Valves and regulators shall avoid cavities, if not functionally required.

- l. Valves and regulators shall not generate contamination, exceeding the specified level, when exposed to the specified environmental and functional tests.

NOTE 1 E.g. during dry cycles.

NOTE 2 Sliding armatures can generate contamination.

NOTE 3 Sliding armatures are susceptible to jamming and wear.

4.2.2.4 Filters

- a. Filters shall not shed particles, exceeding the specified level, during operation and environmental testing.

4.2.2.5 Instrumentation

- a. Sensors introducing cavities shall allow for cleaning by a flushing lance.

NOTE See Annex B.

- b. Cavities or dead end tubing shall allow for thermal and vacuum drying.

NOTE See Annex B.

4.2.2.6 Injectors

- a. The deposition of NVR in capillary tubes and injector bores during operation shall be analysed and reported.

NOTE 1 E.g. during pulse mode.

NOTE 2 See Annex A.

4.2.2.7 Thrust chambers

- a. The deposition of NVR on catalyst beds shall be analysed and reported.

NOTE See Annex A.

4.2.3 System

- a. The system shall allow for ground draining of simulation fluids and of propellants.
- b. Systems requiring cleaning and cleanliness verification shall have no protective filters at fill and drain valves or test ports.
- c. Filtration rate and capacity requirements shall include the flight operation and the contamination introduced by integration and testing at higher build level.

NOTE See Annex A.

- d. The integration of filters should be performed after final cleaning and verification of the related subsystems.

NOTE See Annex B.

- e. Line replaceable components shall be protected by built-in filters.
- f. The system design should enable flow-down cleanliness verification (see clause 4.1g).

4.2.4 Ground support equipment (GSE)

- a. Connect/disconnect interfaces shall be protected from contamination by filters or by procedures

NOTE E.g. purge flow during connection / disconnection.

- b. GSE protective filters shall be at the interfacing point to the flight hardware.
- c. The GSE shall provide for draining and drying interfaces

NOTE E.g. back flush.

- d. The GSE shall provide sampling interfaces and sampling equipment to verify cleanliness.

- e. Filtration of simulation fluids or propellants shall be performed to a cleanliness class equal or better than the propulsion system requirements.

NOTE See Annex A.

4.3 Manufacturing

4.3.1 General

- a. Manufacturing aspects that affect the selection of cleaning techniques shall be reported in conformance with Annex B.

4.3.2 Manufacturing processes

- a. ECSS-Q-ST-70-01 requirements for 'Manufacturing' and 'Assembly and integration' shall apply.
- b. The required proof pressure testing shall be performed after cleaning processes that affect material properties

NOTE E.g. after acid treatment.

4.3.3 Machined parts

- a. Machined parts shall be cleaned as specified for the subsequent manufacturing operations.

NOTE This is also to achieve the final cleanliness level.

- b. Machined parts shall be free of burrs.

NOTE For large items such as diaphragms and bladders, special cleaning procedures can be necessary.

4.3.4 Tubing and manifolds

- a. Tubing, manifolds and transition joints shall be free of burrs, maintaining sharp edges for welding.
- b. Tubing, manifolds and transition joints shall have passed all contaminating handling steps before final cleaning, e.g. bending, flaring, cutting to length and contaminating inspections.
- c. Light oxide films, shall be removed by validated processes, e.g. brushing with a clean stainless steel wire brush, glass blasting (except for flow paths), draw filing, acid pickling.
- d. Grinding shall not be performed on tube end interface surfaces that are subject to welding.

NOTE Debris from the grinding wheel can get embedded in the metal surface. This has been known to cause weld problems due to